**Laboratory Environment Safety and Health Committee**
**Cryogenic Safety Subcommittee**

# MINUTES OF MEETING 03-03

**July 9, 2003**

# FINAL

| **Committee Members Present** | **Committee Members Absent** |
|---|---|
| M. Gaffney | M. Iarocci |
| W. Glenn | P. Kroon |
| S. Kane | J. Muratore |
| E. Lessard (Chairperson) | |
| P. Mortazavi | |
| M. Rehak | |
| R. Travis* (Secretary) | |
| K. C. Wu | |
| (* non-voting) | |

**Visitors**
**G. Ganetis**
**G. McIntyre**

**Agenda:**

1. **Informal Discussions on the Committee Conduct of Operations**

2. **RHIC Snake Magnet #1 Modification**

**Minutes of Meeting:** Appended on pages 2 through 3.

**ESH COMMITTEE MINUTES APPROVED:**

**Signature on File**
**E. Lessard**
**LESHC Chairperson**

**DM2120.**

Chairperson E. Lessard called the third meeting in 2003 of the Laboratory Environmental Safety and Health Committee (LESHC) to order on July 9, 2003 at 3:40 p.m.

1. **Informal Discussions on the Committee Conduct of Operations:**
   - 1.1. E. Lessard welcomed the new LESHC members and thanked them for their support during this time of transition.
   - 1.2. Information was exchanged about LESHC and Cryogenic Committee conduct of operations.
   - 1.3. Revision 2 to the "Proposed Guidelines and R2A2 for the Laboratory Environmental, Safety and Health Committee" had been sent out for Committee Review on July 8th. (The review cycle ends on July 16, 2003.) Revision 2 addresses the combined operation of the LESHC and the Cryogenic Safety Committee. Several members had reviewed the document and offered the following comments:
     - 1.3.1. The guidelines should formally designate a Cryogenic Safety Subcommittee.
     - 1.3.2. The ex-officio members of the LESHC (e.g., M. Gaffney, R. Lee and H. Kahnhauser) should have voting privileges.
     - 1.3.3. The secretary of the former Cryogenic Safety Committee (J. Muratore) should be offered a full (voting) membership in the LESHC.
     - 1.3.4. Ed Lessard agreed to present these recommendations to the Deputy Director for Operations for his concurrence – **Complete**[1].
     - 1.3.5. The Chairman noted that the terms for several members had ended. R. Travis committed to address this – **Complete**[1].

2. **RHIC Snake Magnet # 1 Modification:** E. Lessard invited G. McIntyre to present the proposed modification to the RHIC Snake Magnet # 1. Mr. McIntyre used several drawings from the material that was previously transmitted to the Committee as the basis of his presentation. (The Committee review package is attached as Appendix 1 to these minutes)
   - 2.1. Mr. McIntyre and other attendees made the following points during the course of the presentation and in response to specific Committee questions:
     - 2.1.1. Since the feedthroughs require repair, C-AD would like to take this opportunity to increase the length of the flexlines to reduce heat losses.
     - 2.1.2. The power lead feedthrough failures for snake magnet # 1 were caused by electrical shorts due to ice buildup between the ceramic and the conductors. This was attributed to the orientation of the turret. The existing flexline configuration was not a contributor.
     - 2.1.3. A similar feedthough design (without the splice can) is performing well at 22 locations in the RHIC ring.
     - 2.1.4. Due to the amount of wires involved, the electrical resistivity of the splice is not considered to be a concern.
     - 2.1.5. Since the splices are staggered within the splice box, they aren't expected to impede helium flow. At full current operation, only about 50% of the maximum cooling flow was required.

[1] This action was completed prior to the issuance of these minutes.

2.1.6. The cold mass is presently under a continuous nitrogen purge. This modification will require a purge evacuation system. The system will exhaust to an area within the RHIC tunnel that will be posted for the ODH hazard. Entry into the posted area will require personal oxygen monitoring.

2.1.7. A Committee member performed selected confirmatory stress calculations of the flex line and the splice can. (They are included as Appendix 2 to these minutes.) The proposed design has a hole in the splice can head which will require a C-AD stress analysis.

2.2. The following motion was crafted by the Committee:

Motion 1: The Committee recommends the approval of the proposed modifications to RHIC Snake Magnet # 1, subject to the following conditions.

1. Review the Magnet Division calculation, "Helical Magnet Program, Power Lead Redesign" by S. Plate and M. Rehak, dated May 5, 2000 (Appendix 3) for applicability to this proposed design – **Complete**[1].
2. The design should have an additional anchor between the splice can and the turret – **Complete**[1].
3. Submit the rationale for the ODH access controls around the work area to the Committee – **Complete**[1].
4. Evaluate the hole in the head of the splice can for compliance with the ASME Boiler and Pressure Vessel (B&PV) Code – **Complete**[1].
5. Per the ASME B&PV Code, a pressure test of the modification is required prior to operation.

2.3. A call for a Motion was made by E. Lessard.

2.3.1. Recommendation for Approval of the motion was made by W. Glenn.

2.3.2. Seconded by E. Lessard.

2.3.3. The Motion was approved by vote of six in favor, none opposed, and one abstention.

3. The Meeting was adjourned at 4:50 p.m.

APPENDIX I TO LESHC 03-03

Edward Lessard
Chairman, BNL ES&H / Cryogenic Safety Committee
Building 911B
July 01, 2003

Dear Mr. Chairman,
Failure of the power lead feedthroughs in the first snake (snake #1) will precipitate the opening of both power leads in this magnet. To reduce the heat loss from these lead lines the lead length will be increased to match the follow-on snakes (snakes #2 - #4). The proposed repair is similar to CSC-approved valve box repairs. This proposed repair is smaller in scale, with the splice pipe being one-third the size of that used in the valve box modification, BNL drawing # 32025119A.

To accommodate the splice required to extend these lines, the following modifications are proposed: (all components discussed are 304L or 316L SST)

1. The existing flexline will be cut free of the failed feedthrough flange.
2. The existing flexline will be anchored to the cold mass, as shown in the attached drawing #1. Since the flexline contracts towards the magnet's center post, as the magnet does, the flexline will see little or no tensile stress from this movement.
3. Flanges (2.37"OD X 1.25"ID X .375 thick) are welded to the 1.25"OD X 0.49" wall flexline cuff via a 0.06" fillet weld using the GTAW process through one of two options. (drawing #2)
4. As shown in attached drawing #3, a second identical flexline is installed in the newly positioned turret. The flexline/piping configuration is similar to the power lead installation in snake magnets #2 - #4. The second flexline is welded to the replacement feedthrough on one end and a 2.37"OD X 1.25"ID X .375 thick flange on the other.
5. A 2.5"OD X 0.065wall tube (splice can) slides over the original flexline. The cable splice is then completed and electrically tested.
6. With testing complete the tube slides over the flanges and is welded to the flanges using a 0.06" fillet welded produced with the GTAW process.
7. The remaining components of the assembly are welded in place. The G10 tube mount is bolted to the cold mass anchor.
8. The system is pressure leak checked.

An overview of the magnet is also provided.

Calculations are attached for loads and/or stresses acting on the G10 plate, the splice can flanges and welds and needed contraction in the flexlines.

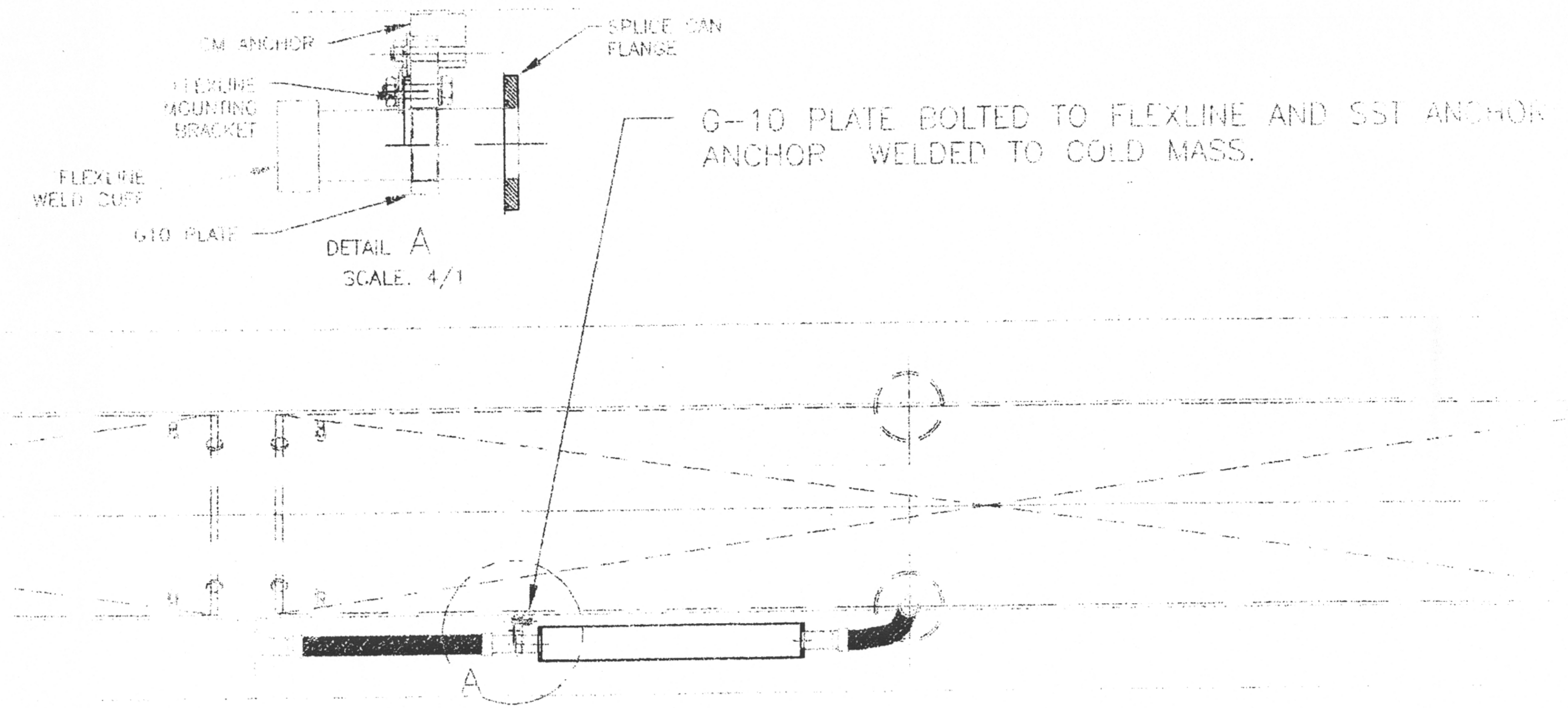
Please contact me if the CSC wishes to conduct a full review or with any questions or comments. This installation is scheduled for mid-July. I apologize for this compressed schedule, but I lost time in finding the new committee chairperson.

Thank you for your attention to this matter.

Best regards,

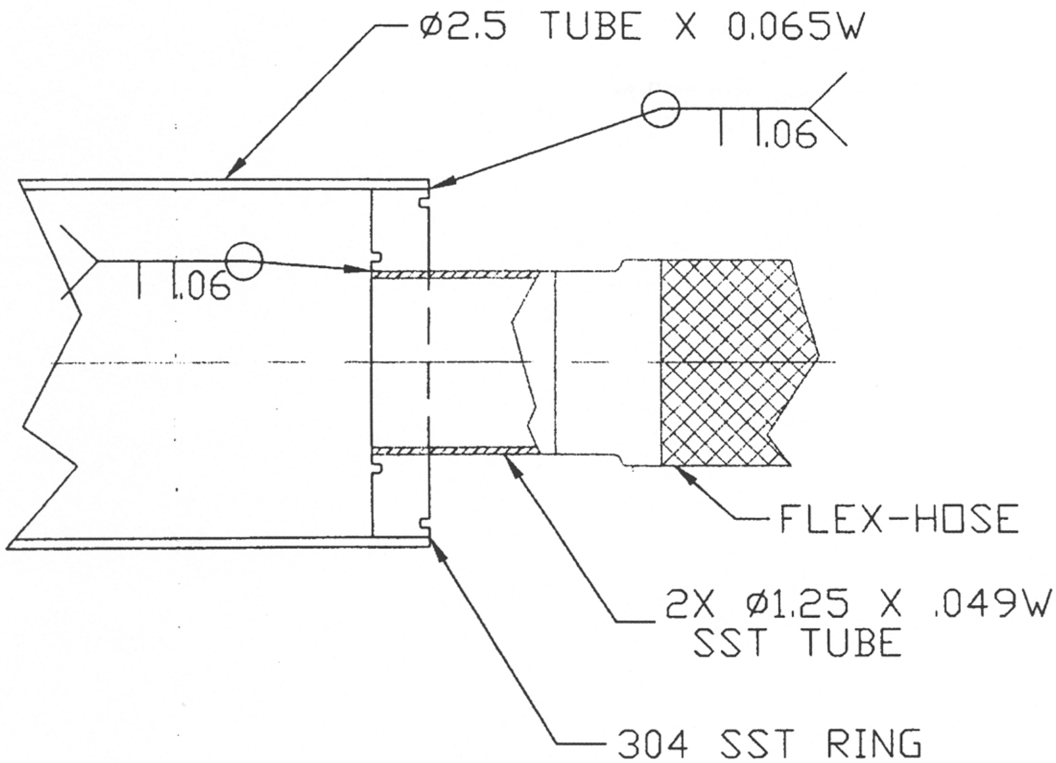
MAC

Gary McIntyre
(x7037) mac@bnl.gov


CM ANCHOR
SPLICE CAN FLANGE
FLEXLINE MOUNTING BRACKET
FLEXLINE WELD CUFF
G10 PLATE
DETAIL A
SCALE: 4/1
G-10 PLATE BOLTED TO FLEXLINE AND SST ANCHOR
ANCHOR WELDED TO COLD MASS.
A

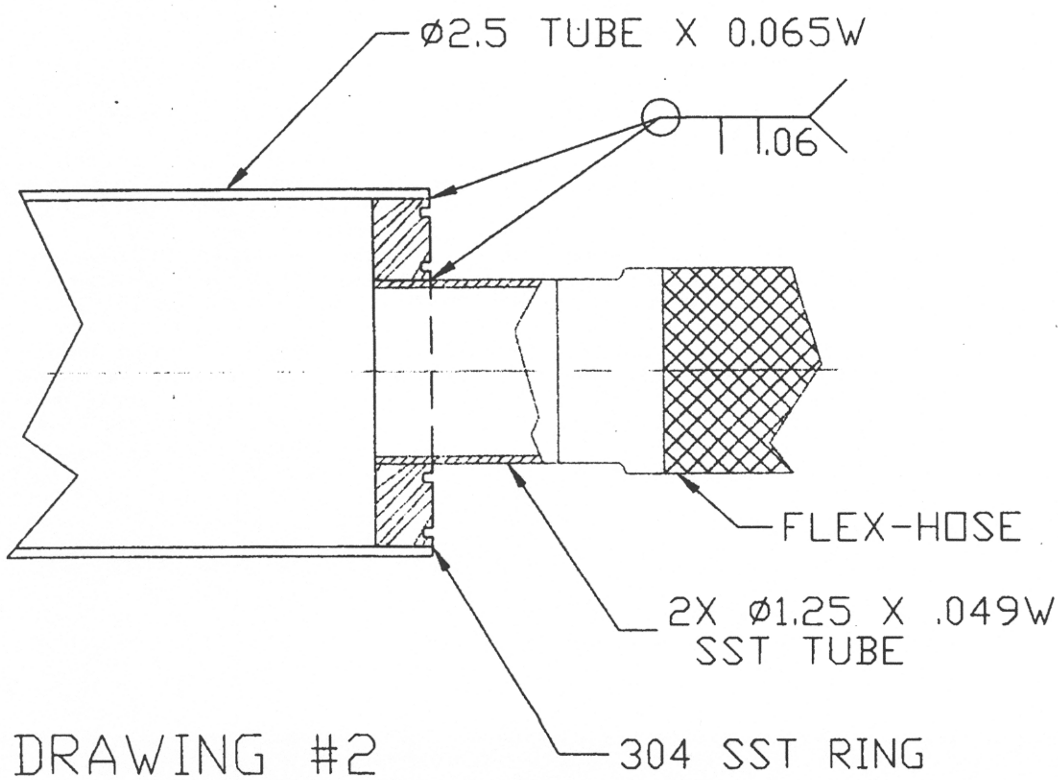
DRAWING #1

YI9 SNAKE POWERLEAD REPAIR PROPOSED CONFIGURATION




SnakePWRLDFX.DWG 06/16/03

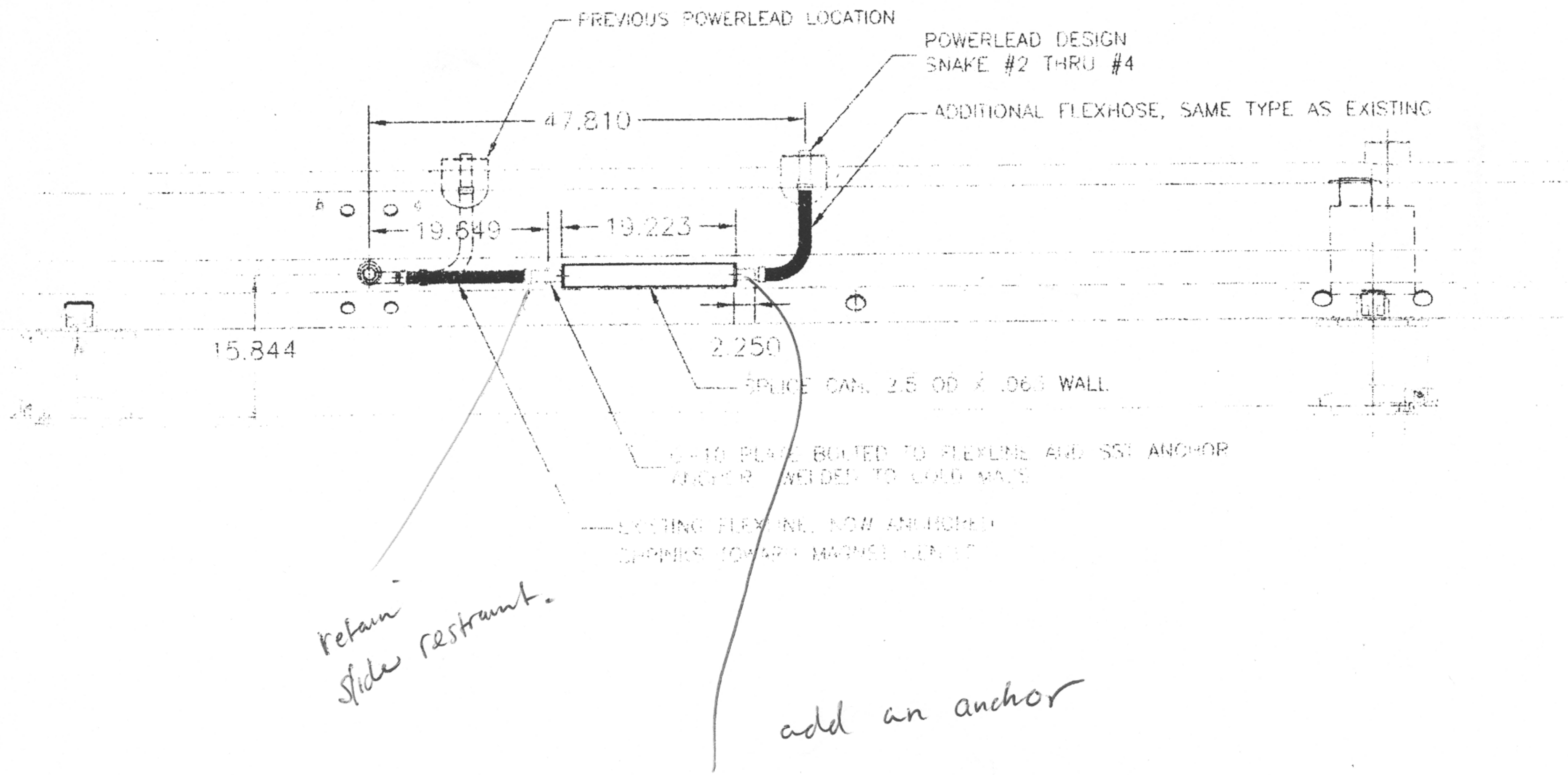
YI9 SNAKE POWERLEAD REPAIR PROPOSED CONFIGURATION



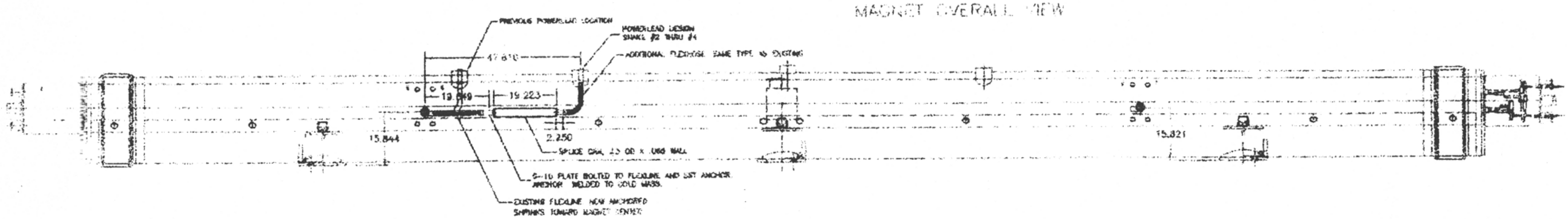

DRAWING #2

SnakePWRLDFX.DWG 06/16/03

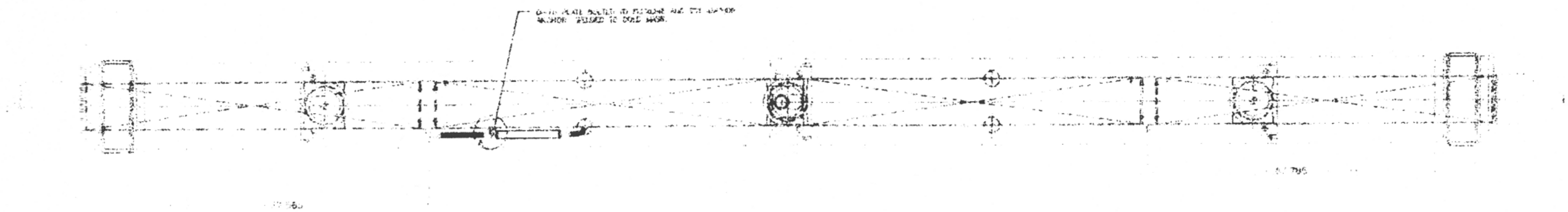
# DRAWING #3


PREVIOUS POWERLEAD LOCATION
POWERLEAD DESIGN
SNAKE #2 THRU #4
ADDITIONAL FLEXHOSE, SAME TYPE AS EXISTING
47.810
19.649
19.223
2.250
15.844
WALL
retain
slide restraint.
add an anchor

MAGNET OVERALL VIEW




ELEVATION VIEW, AS POSITIONED IN THE TUNNEL VIEWED FROM THE INNER AISLE



PLAN VIEW, AS VIEWED LOOKING DOWN

Calculation to find the maximum stresses in the flanges of the splice can:

Find the deflection and stress on a disk. Outer edge is fixed with inner edge guided.
Roark's table 24, 2f, page 407.

$E_{sst} := 28.5 \cdot 10^6 \cdot psi$ $\quad \nu := 0.26$

plate thickness $t_{plate} := .375 \cdot in$ groove depth $g_{depth} := .065 \cdot in$

effective thickness, t: $t := t_{plate} - g_{depth}$ $\quad t = 0.31 \cdot in$ $\quad r_0 := 1.25 \cdot in$

RHIC max. test pressure is 318 psi.

Pressure, uniform load: $q := 318 \cdot psi$ Plate constant, D: $D := \dfrac{E_{sst} \cdot t^3}{12 \cdot (1 - \nu^2)}$

outer edge, a: $a := 2.38 \cdot in$ inner edge, b: $b := r_0$ load radius, r0:

Calculating formula constants:

$$C_2 := \frac{1}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2 \cdot \left(1 + 2 \cdot \ln\left(\frac{a}{b}\right)\right)\right] \qquad C_2 = 0.092$$

$$C_5 := \frac{1}{2} \cdot \left[1 - \left(\frac{b}{a}\right)^2\right] \qquad C_5 = 0.362$$

$$C_8 := \frac{1}{2} \cdot \left[1 + \nu + (1 - \nu) \cdot \left(\frac{b}{a}\right)^2\right] \qquad C_8 = 0.732$$

$$L_{11} := \frac{1}{64} \cdot \left[1 + 4 \cdot \left(\frac{r_0}{a}\right)^2 - 5 \cdot \left(\frac{r_0}{a}\right)^4 - 4 \cdot \left(\frac{r_0}{a}\right)^2 \cdot \left[2 + \left(\frac{r_0}{a}\right)^2\right] \cdot \ln\left(\frac{a}{r_0}\right)\right] \qquad L_{11} = 1.654 \cdot 10^{-3}$$

$$L_{14} := \frac{1}{16} \cdot \left[1 - \left(\frac{r_0}{a}\right)^4 - 4 \cdot \left(\frac{r_0}{a}\right)^2 \cdot \ln\left(\frac{a}{r_0}\right)\right] \qquad L_{14} = 0.013$$

$$L_{17} := \frac{1}{4} \cdot \left[1 - \frac{1 - \nu}{4} \cdot \left[1 - \left(\frac{r_0}{a}\right)^4\right] - \left(\frac{r_0}{a}\right)^2 \cdot \left[1 + (1 + \nu) \cdot \ln\left(\frac{a}{r_0}\right)\right]\right] \qquad L_{17} = 0.082$$

Radial reaction at outer diameter, b:

$$M_{rb} := q \cdot a^2 \cdot \left(\frac{L_{14}}{C_5}\right) \qquad M_{rb} = 66.345 \cdot lbf$$

Reaction force/unit circumferential length:

$$Q_a := \frac{-q}{2 \cdot a} \cdot \left(a^2 - r_0^{\,2}\right) \qquad Q_a = -274.034 \cdot \frac{lbf}{in}$$

Radial reaction at inner diameter, a:

$$M_{ra} := -q \cdot a^2 \cdot \left(L_{17} - \frac{C_8}{C_5} \cdot L_{14}\right) \qquad M_{ra} = -99.773 \cdot lbf$$

Stress at the ID:

$$\sigma_{rb} := \frac{6 \cdot M_{rb}}{t^2} \qquad \sigma_{rb} = 4.142 \cdot 10^3 \cdot psi \qquad N_{rb} := \frac{36000 \cdot psi}{\left|\sigma_{rb}\right|} \qquad N_{rb} = 8.691 \qquad \text{OK}$$

Stress at the OD:

$$\sigma_{ra} := \frac{6 \cdot M_{ra}}{t^2} \qquad \sigma_{ra} = -6.229 \cdot 10^3 \cdot psi \qquad N_{ra} := \frac{36000 \cdot psi}{\left|\sigma_{ra}\right|} \qquad N_{ra} = 5.779 \qquad \text{OK}$$

Results are acceptable, being far below the yield strength of 36,000 psi for annealed 304SST.

Calculations made to prove out "Snake Magnet Power Lead Change".
The run is the same as in Snake magnets #2 thru 4, but include a splice can & a second flexline.

1) What expansion/contraction allowance is needed in the assembly?

Design contains two flexline assemblies per line. One is anchored to the cold mass (CM) by a welded elbow at one end and via a G10 plate bolted to a welded CM anchor at the other end. The second flexline is welded to the first flexline at one end and the attached to the power lead feethrough (BNL p/n: 12011385 / RD12011392) at the other.

Flexline allowable lateral offset: $Stroke_{HSD} := 6.0 \cdot in$

The elbow/G-10 anchored flexline maintains approximately the same temperature as the CM & shrinks in the same direction as the CM. Differential contraction should be minimal. The second flexline is 273K at one end and assumed (worst case) 4K at the other:

Length from the first flexline G10 plate/anchor to feedthru weld is: $L_{pipe} := 35 \cdot in$

Total length: $L_{total} := L_{pipe}$ $\qquad L_{total} = 35 \, in$

Contraction multiplier for SST at 4.2K: $Mlt_c := 0.00325 \cdot \frac{in}{in}$

Expansion needed for the second flexline:

$Expansion_{2Flex} := L_{total} \cdot Mlt_c$ $\qquad Expansion_{2Flex} = 0.114 \, in$

Power Lead Flexline must be set with at least $2 \cdot Expansion_{2Flex} = 0.228 \, in$ offset in line during assembly set-up and prior to welding.

There is sufficient offset in the feedthru flexline to allow for this movement.

2) Can the G-10 anchor resist the pipe force loads without failure?

Determine the load transmitted to the support by the pipe force:
The effective bellows area of the flexline is used.

$OD_{utilbellows} := 1.45 \cdot in$

$D_{effbellows} := OD_{utilbellows}$

$A_{effbellows} := \pi \cdot \frac{D_{effbellows}^2}{4}$ $\qquad A_{effbellows} = 1.651 \, in^2$

Force produced by the max. line pressure (Ppipe), then transmitted into the anchor:

$P_{pipe} := 318 \cdot psi$ $\qquad F_{pipe} := P_{pipe} \cdot A_{effbellows}$ $\qquad F_{pipe} = 525.113 \, lbf$

Determining the reaction force and reaction moment in the G-10:
Roarks (pg 100), Table 3, 1a, one end fixed, one end free.

Distance from the pipe/plate fastener to the plate/anchor fastener:

$$l := .648\cdot in$$

Reaction force creating stress in the G10: $R_B := (F_{pipe})$ $\quad R_B = 525.113 \cdot lbf$

Reaction moment in the G10 at the CM anchor:

$$M_B := (-F_{pipe})\cdot(l) \qquad M_B = -340.273 \cdot in\cdot lbf$$

Determine the stress in the G-10 : $width_{G10} := (1.75\cdot in)$ $\quad thk_{G10} := .5\cdot in$

$$A_{G10} := thk_{G10}\cdot width_{G10} \qquad A_{G10} = 0.875 \cdot in^2 \qquad y_{G10} := \frac{thk_{G10}}{2}$$

$$I_{G10} := \frac{width_{G10}\cdot thk_{G10}^{\ 3}}{12} \qquad I_{G10} = 0.018 \cdot in^4 \qquad E_{G10} := 3.2\cdot 10^6\cdot psi$$

(Deutschman, et.al., pg 307)

$$\sigma_{G10max} := \frac{R_B}{A_{G10}} + \frac{-M_B\cdot y_{G10}}{I_{G10}} \qquad \sigma_{G10max} = 5.267\cdot 10^3 \cdot psi$$

Tensile Strength of G10 (with warp): $S_{G10} := 3.6\cdot 10^4\cdot psi$

$$SF := \frac{S_{G10}}{\sigma_{G10max}} \qquad SF = 6.835$$

OK

Deflection of the G10 support:

$$def_{G10} := \frac{-F_{pipe}\cdot l^3}{3\cdot E_{G10}\cdot I_{G10}} \qquad def_{G10} = -8.165\cdot 10^{-4} \cdot in$$

OK

All results are acceptable.

**Analysis of RHIC snake magnet feedthrough fix**

**Initial Parameters**

$ts := 0.065 \cdot in$ $S := 16300 \cdot psi$ $P := (318) \cdot psi$ $OD := 2.5 \cdot in$ $ID := OD - 2 \cdot ts$ $R := \frac{ID}{2}$ $E := 0.45$

**Calculate Required Cylinder Thickness**

Circumferential Stress (Logitudinal Joints) (UG-27(c)(1))

Perform Initial Checks

$0.385 \cdot S \cdot E = 2824 \cdot psi$ This is greater than P. OK

$\frac{R}{2} = 0.593 \cdot in$ This is greater than t. OK

Calculate Required Thickness and Allowable Pressure

$tr := \frac{P \cdot R}{S \cdot E - 0.6 \cdot P}$ $tr = 0.053 \cdot in$ This is less than the design thickness of 0.065. OK

$\frac{S \cdot E \cdot ts}{R + (0.6 \cdot ts)} = 389.522 \cdot psi$ This is greater than the design pressure of 318 psia. OK

Longitudinal Stress (Circumferential Joints) (UG-27(c)(2))

Perform Initial Checks

$1.25 \cdot S \cdot E = 9169 \cdot psi$ This is greater than P. OK

$\frac{R}{2} = 0.593 \cdot in$ This is greater than t. OK

Calculate Required Thickness and Allowable Pressure

$\frac{P \cdot R}{2 \cdot S \cdot E + 0.4 \cdot P} = 0.025 \cdot in$ This is less than the design thickness of 0.065. OK

$\frac{2 \cdot S \cdot E \cdot ts}{R - (0.4 \cdot ts)} = 822.735 \cdot psi$ This is greater than the design pressure of 318 psia. OK

The limiting stress on the shell is hoop, for a limiting pressure of 389 psi.

**Calculate Required Head Thickness**

$m := \frac{tr}{ts}$ $C := 0.2$ $S := 16300 \cdot psi$ See UG-34 for appropriate C factor.

$ID \cdot \sqrt{\frac{C \cdot P}{S \cdot E}} = 0.221 \cdot in$ This is the minimum head thickness for a flat circular head.

Calculate Tension on the Weld for the Head

$weld\_leg := 0.06 \cdot in$ $\pi \cdot R^2 = 4.412 \cdot in^2$

$$Aw := \pi \cdot \left[ \left( \frac{OD}{2} + \frac{weld\_leg}{2} \right)^2 - \left( \frac{OD}{2} - \frac{weld\_leg}{2} \right)^2 \right]$$ $Aw = 0.471 \cdot in^2$ $Fp := P \cdot \pi \cdot R^2$ $Fp = 1403 \cdot lbf$

$\frac{Fp}{Aw} = 2977 \cdot psi$ This stress is less than 19% of the allowable stress. $\frac{\frac{Fp}{Aw}}{S} = 0.183$

**Analysis of RHIC snake magnet feedthrough fix**

**Initial Parameters**

$ts := 0.049 \cdot in$ $\quad S := 16300 \cdot psi$ $\quad P := (318) \cdot psi$ $\quad OD := 1.25 \cdot in$ $\quad ID := OD - 2 \cdot ts$ $\quad R := \frac{ID}{2}$ $\quad E := 0.45$

**Calculate Required Cylinder Thickness**

Circumferential Stress (Logitudinal Joints) (UG-27(c)(1))

Perform Initial Checks

$0.385 \cdot S \cdot E = 2824 \cdot psi$ This is greater than P. OK

$\frac{R}{2} = 0.288 \cdot in$ This is greater than t. OK

Calculate Required Thickness and Allowable Pressure

$$tr := \frac{P \cdot R}{S \cdot E - 0.6 \cdot P}$$

$tr = 0.026 \cdot in$ This is less than the design thickness of 0.049. OK

$\frac{S \cdot E \cdot ts}{R + (0.6 \cdot ts)} = 593.682 \cdot psi$ This is greater than the design pressure of 318 psia. OK

Longitudinal Stress (Circumferential Joints) (UG-27(c)(2))

Perform Initial Checks

$1.25 \cdot S \cdot E = 9169 \cdot psi$ This is greater than P. OK

$\frac{R}{2} = 0.288 \cdot in$ This is greater than t. OK

Calculate Required Thickness and Allowable Pressure

$\frac{P \cdot R}{2 \cdot S \cdot E + 0.4 \cdot P} = 0.012 \cdot in$ This is less than the design thickness of 0.049. OK

$\frac{2 \cdot S \cdot E \cdot ts}{R - (0.4 \cdot ts)} = 1291.93 \cdot psi$ This is greater than the design pressure of 318 psia. OK

The limiting stress on the shell is hoop, for a limiting pressure of 594 psi.

Calculate Tension on the Weld for the Head

$weld\_leg := 0.06 \cdot in$ $\quad \pi \cdot R^2 = 1.042 \cdot in^2$

$$Aw := \pi \cdot \left[\left(\frac{OD}{2} + \frac{weld\_leg}{\sqrt{2}}\right)^2 - \left(\frac{OD}{2}\right)^2\right]$$

$Aw = 0.172 \cdot in^2$ $\quad Fp := P \cdot \pi \cdot R^2$ $\quad Fp = 331 \cdot lbf$

$\frac{Fp}{Aw} = 1924 \cdot psi$ This stress is less than 12% of the allowable stress. $\frac{\frac{Fp}{Aw}}{S} = 0.118$

APPENDIX 3 TO LESHC 03-03

5 MAY 2000

# HELICAL MAGNET PROGRAM

## POWER LEAD REDESIGN

S. Plate

M. Rehak

# HELICAL MAGNET GAS-COOLED POWER LEAD DESIGN PARAMETERS

powerlead.xls 20-Apr-00 S. Plate

original design as built

| | coil terminals to junction board* | wires from board to elbow/hose | wires through elbow/hose | wires in can to pins | pins, cold side | pins in ceramic | pins, warm side | wires from pins to blocks | connection blocks |
|---|---|---|---|---|---|---|---|---|---|
| **length (inches)** | 37.0 | 10.9 | 21.1 | 6.0 | 1.3 | 1.8 | 1.8 | 11.5 | see item descr |
| **length (cm)** | 94.0 | 27.7 | 53.6 | 15.2 | 3.3 | 4.6 | 4.6 | 29.2 | see item descr |
| **cumulative length (cm)** | 94.0 | 121.7 | 175.3 | 190.5 | 193.8 | 198.4 | 202.9 | 232.2 | |
| **temperature** | 4 K | 4 K | transitional | transitional | transitional | transitional | transitional | transitional | 300 K |
| **environment** | FF He, 100 g/sec | FF He, 100 g/sec | FF He, ? g/sec | FF He, ? g/sec | FF He, ? g/sec | ceramic | air in enclosure | air in enclosure | air in enclosure |
| **items present** | A | B, C, D | B, C, D | B, C, D | E, F, F | E, F, F | E, F, F | G, C ,H | J, K, L |
| **item quantities** | 4 | 16, 2, 2 | 16, 2, 2 | 16, 2, 2 | 4, 2, 6 | 4, 2, 6 | 4, 2, 6 | 16, 2, 2 | 4, 2, 2 |

**item A description:**

superconductor cable, 8 wire triplets per cable (@320A nominal current in cable)
wire triplet cross section = 3 x .0268" dia = .00169 sq in (= .0135 sq in total per cable)
Cu / NbTi ratio = 1.75 : 1
wire triplet insulation is extruded Tefzel, .006" radial thickness
cable insulation is .003" radial thickness Kapton, .007" thickness extruded Tefzel over top

**item B description:**

#10 stranded copper wire (@320A/4 nominal current)
cross section = .00815 sq in
wire insulation is .003" Kapton and .007" extruded Tefzel

**item C description:**

#10 stranded copper wire (normally unpowered)
cross section = .00815 sq in
wire insulation is .003" Kapton and .007" extruded Tefzel

**item D description:**

voltage tap cable (unpowered), qty of 3 #28 stranded copper wires per cable
cross section = 3 x .000126 sq in = .000378 sq in total per cable
wire insulation is .003" Kapton and .007" extruded Tefzel

**item E description:**

feedthru pin, copper, .500" dia x 4.9" long total

**item F description:**

feedthru pin, copper, .094 dia x 4.7" long total

**item G description:**

#4 stranded copper wire (@320A/4 nominal current)
cross section = .0328 sq in
wire insulation is synthetic rubber (EPDM), .090 thick

**item H description:**

voltage tap cable (unpowered)
qty of 3 #22 stranded copper wires per cable
cross section = 3 x .0005 sq in = .00152 sq in total per cable
wire insulation is .003" Kapton and .007" extruded Tefzel

**item J description:**

connection block, 3.5" x 2.5" x .75"
mounted to G-10 on smallest face

**item K description:**

hypertronics connector, negligible thermal mass

**item L description:**

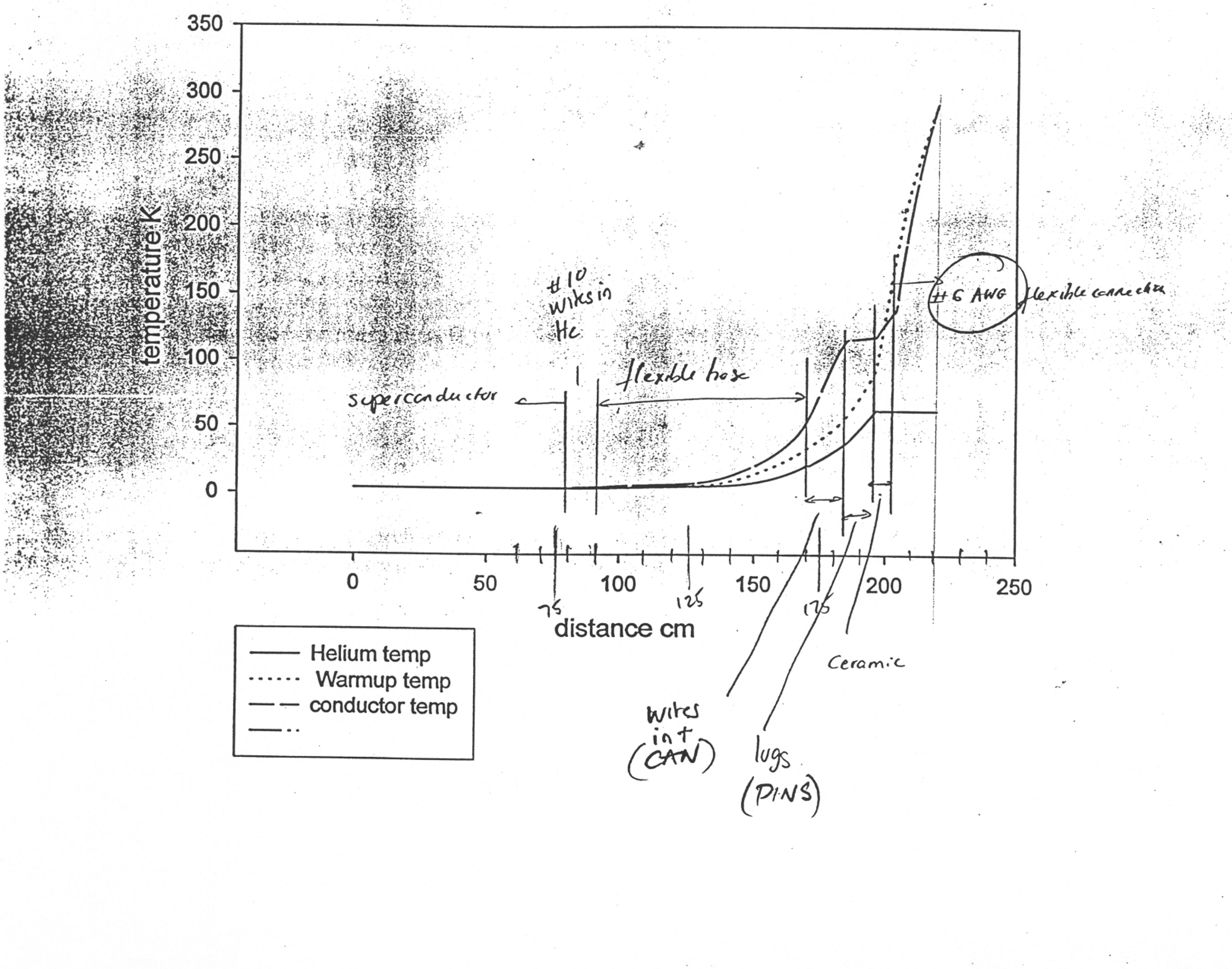
triple screw terminal, negligible thermal mass

*note 1: v-tap wires from coil terminals to junction board are neglected

note 2: flex hose 1.0 ID x 0.010 thhick wall; can 6.21 ID x 0.200 wall

ANALYSIS OF
10 JAN 1998

Snake magnet lead
Temperature vs distance



# REDESIGNED POWER LEAD RESULTS

1. UNPOWERED & NO FLOW

   FEEDTHROUGH TEMP IS ~275K (~0°C)
   AT WARM SIDE

2. OPERATING @ 320A NOMINAL CURRENT (BOTH STORAGE UNITS)

   FEEDTHRU TEMP IS ~240K, WARM SIDE.
   BRING THIS UP TO FREEZING POINT WITH HEATER.

   $\dot{m}$ = 0.1 g/sec = 0.075 g/sec/kA

3. OPERATING @ SAME 320A, BUT $\dot{m}$ REDUCED 20% (SAFETY MARGIN)

   FEEDTHRU TEMP IS ~ 270K

   SAME MASS FLOW = 0.1 g/sec = 0.0625 g/sec/kA

   IMPENDING RUNAWAY AT THIS MASS FLOW RATE

4. OPERATING @ 380A (BOTH STORAGE UNITS)

   F'THRU TEMP ~ 140K (INCR MASS FLOW)

   $\dot{m}$ = 0.18 g/sec = 0.12 g/sec/kA

5. OPERATING @ SAME 380A, BUT $\dot{m}$ REDUCED 20%

   F'THRU TEMP ~ 170K (SAME MASS FLOW)

   IMPENDING RUNAWAY AT THIS FLOW RATE

Monday April 24 2000

M.Rehak

**Lead design for helical coil magnet**

The leads for the helical coil magnets, of which there are 24, consist of 16 conductors carrying 80 A each for a total of 1280 A. Parameters and drawings are included at the end of this document. The lead consists of simple wires in a flexible tube. This is an inexpensive design to build but its efficiency decreases rapidly as current values are higher.

There are already two existing helical magnet leads in place. These have large frost balls when there is no current and no flow, indicating a high conductive heat load, The design of these leads was based on an erroneous current value of 125 A per conductor instead of 80 A, and it was built 52 cm long instead of 75 cm. The operating mass flow was 0.15 g/sec/kA which is more than double the optimal 0.06 /sec/KA. A different type of lead with better heat exchange would have been needed. For all these reasons, a redesign was in order and the results are presented below.

There are two requirements to meet:

1) The lead should be reasonably efficient when powered and cooled. As a reference the CQS leads are designed for 0.09 g/sec/kA and the theoretical optimal value is 0.06 g/sec/kA. There are 492 leads powering corrector quadrupole sextupole magnet in the RHIC accelerator. These leads are similar in design but carry a total of 600 A and are 91 cm long.

2) With no flow and no current the lead should come out of the cryostat at a temperature around freezing. The CQS leads just condense. (WITH HEATERS DURING FLOW AND POWER)

The existing design should be modified as follows:

A) The length must be increased from the present 52 cm to 150 cm.

B) The number of #4 wires providing flexible connections at the warm end could be increased from 16 to 24.

# HELICAL MAGNET POWER LEAD REDESIGN

4 MAY 2000

| ORIGINAL ANALYSIS | | WHAT WAS BUILT | |
|---|---|---|---|
| ~80 cm OF S.C. = 31.5" | | 37" | |
| ~10 cm OF WIRES IN He = 4" | 35.5' | 11" | 38" |
| ~80 cm OF WIRES IN HOSE = 31.5" | | 21" | |
| ~15 cm OF WIRES IN CAN = 6" | | 6" | |
| ~10 cm OF PINS ON "COLD SIDE" = 4" | | 1.3" | |
| ~10 cm OF CERAMIC = 4" | | 1.8" | |
| ~15 cm OF WIRES ON "WARM SIDE" = 6" | | 13" | |
| (WIRE SIZE = #6 AWG) | | (#4 AWG) | |

| ORIG. ANALYSIS PARAMETERS | OPERATING PARAMETERS |
|---|---|
| 125 A IN EACH OF (16) #10 AWG WIRES | 80 A EACH |
| (2) #10 AWG w/ NO CURRENT | ✓ OK |
| (12) #22 AWG w/ NO CURRENT | (9) #28 AWG |
| COLD END OF COPPER LEAD CONNECTED TO STORAGE UNIT USING 4 S.C. CABLES, 8 WIRES PER CABLE | ✓ OK |
| $\dot{m}$, NO CURRENT = 0.1 g/sec | N/A |
| $\dot{m}$ @ RATED CURRENT = 0.3 g/sec = 0.15 g/sec/kA | |
| THEORETICAL BEST = 0.06 g/sec/kA | |
| HEAT LOAD = 0.3 W | N/A |

SNAKE LEAD OPERATING

(4x 320 A)

1280 A 0.075 g/sec/kA 150 cm flex hose 16 of AWG#4

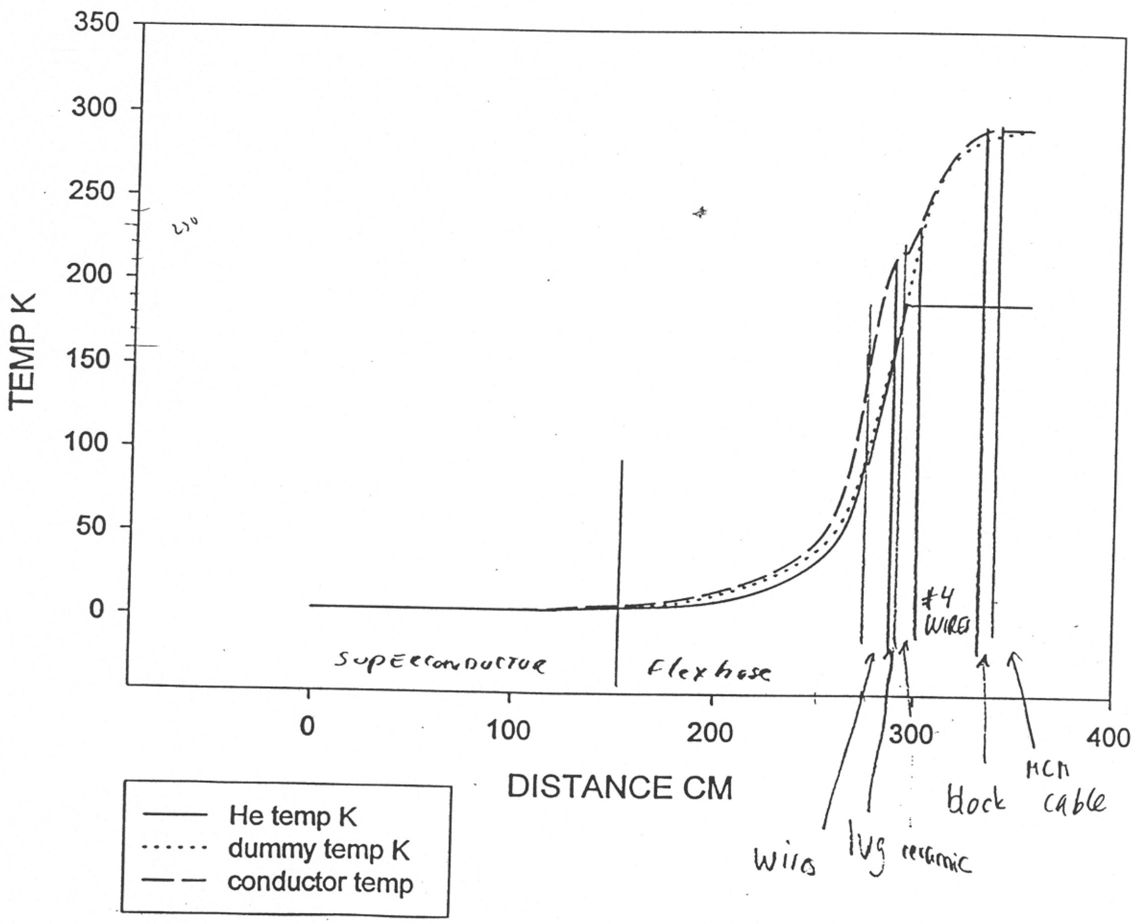



FIG. 2

# HELICAL MAGNET GAS-COOLED POWER LEAD DESIGN PARAMETERS

05-May-00 S. Plate

redesigned at 150 cm length

| | coil terminals to junction board* | wires from board to elbow/hose | wires through elbow/hose | wires in can to pins | pins, cold side | pins in ceramic | pins, warm side | wires from pins to blocks | connection blocks |
|---|---|---|---|---|---|---|---|---|---|
| **length (inches)** | 37.0 | 10.9 | 59.0 | 6.0 | 1.3 | 1.8 | 1.8 | 11.5 | see item descr |
| **length (cm)** | 94.0 | 27.7 | 149.9 | 15.2 | 3.3 | 4.6 | 4.6 | 29.2 | see item descr |
| **cumulative length (cm)** | 94.0 | 121.7 | 271.5 | 286.8 | 290.1 | 294.6 | 299.2 | 328.4 | |
| **temperature** | 4 K | 4 K | 4K to ~160K | ~220K | ~220K | ~240K | ~240K | ~240K to ~290K | 300 K |
| **environment** | FF He, 100 g/sec | FF He, 100 g/sec | FF He, .095 g/sec | FF He, .095 g/sec | FF He, .095 g/sec | ceramic | air in enclosure | air in enclosure | air in enclosure |
| **items present** | A | B, C, D | B, C, D | B, C, D | E, F, F | E, F, F | E, F, F | G, C ,H | J, K, L |
| **item quantities** | 4 | 16, 2, 2 | 16, 2, 2 | 16, 2, 2 | 4, 2, 6 | 4, 2, 6 | 4, 2, 6 | 16, 2, 2 | 4, 2, 2 |

**item A description:**

superconductor cable, 8 wire triplets per cable (@320A nominal current in cable)
wire triplet cross section = 3 x .0268" dia = .00169 sq in (= .0135 sq in total per cable)
Cu / NbTi ratio = 1.75 : 1
wire triplet insulation is extruded Tefzel, .006" radial thickness
cable insulation is .003" radial thickness Kapton, .007" thickness extruded Tefzel over top

**item B description:**

#10 stranded copper wire (@320A/4 nominal current)
cross section = .00815 sq in
wire insulation is .003" Kapton and .007" extruded Tefzel

**item C description:**

#10 stranded copper wire (normally unpowered)
cross section = .00815 sq in
wire insulation is .003" Kapton and .007" extruded Tefzel

**item D description:**

voltage tap cable (unpowered), qty of 3 #28 stranded copper wires per cable
cross section = 3 x .000126 sq in = .000378 sq in total per cable
wire insulation is .003" Kapton and .007" extruded Tefzel

**item E description:**

feedthru pin, copper, .500" dia x 4.9" long total

**item F description:**

feedthru pin, copper, .094 dia x 4.7" long total

**item G description:**

#4 stranded copper wire (@320A/4 nominal current)
cross section = .0328 sq in
wire insulation is synthetic rubber (EPDM), .090 thick

**item H description:**

voltage tap cable (unpowered)
qty of 3 #22 stranded copper wires per cable
cross section = 3 x .0005 sq in = .00152 sq in total per cable
wire insulation is .003" Kapton and .007" extruded Tefzel

**item J description:**

connection block, 3.5" x 2.5" x .75"
mounted to G-10 on smallest face

**item K description:**

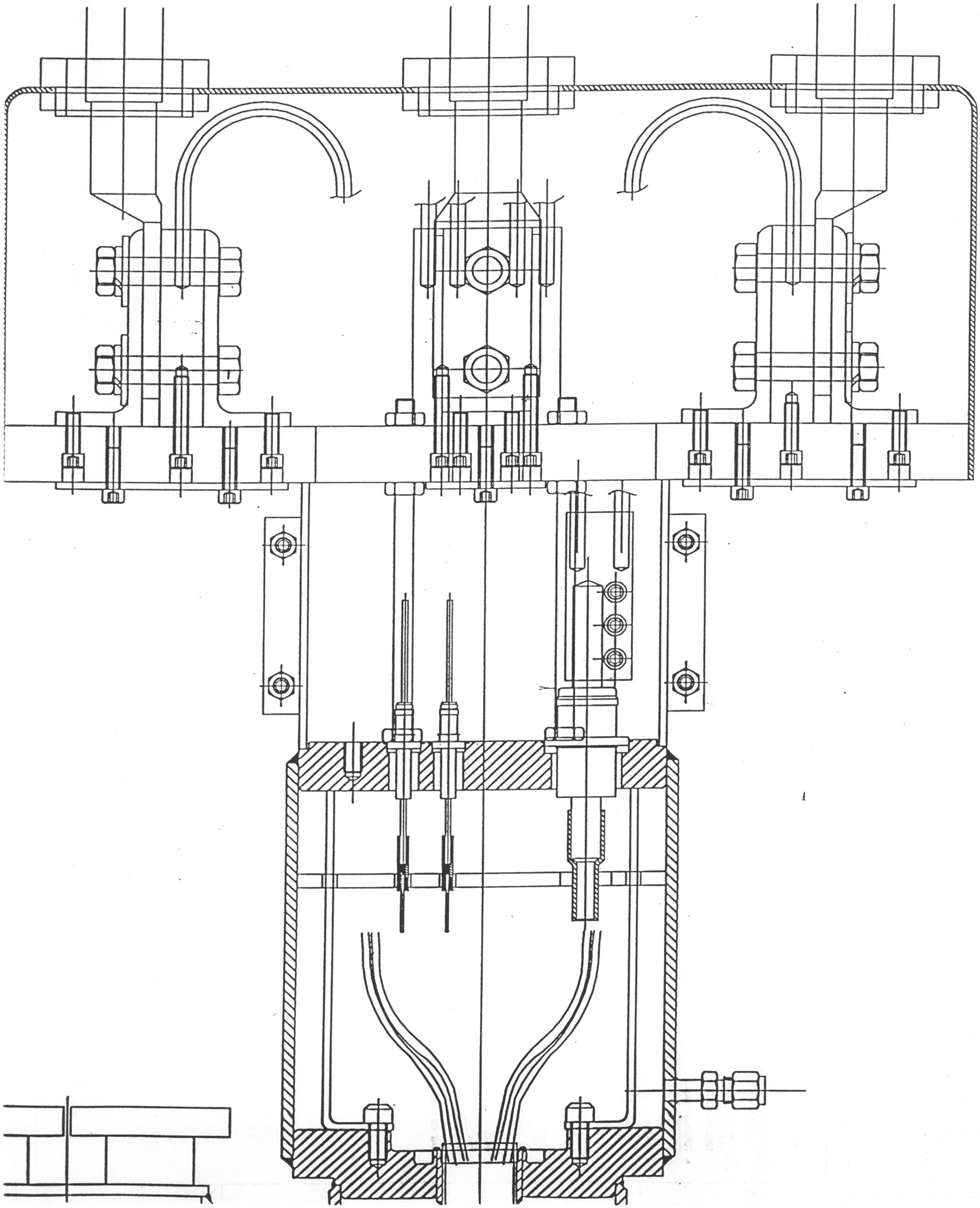
hypertronics connector, negligible thermal mass

**item L description:**

triple screw terminal, negligible thermal mass

*note 1: v-tap wires from coil terminals to junction board are neglected

note 2: flex hose 1.0 ID x 0.010 thhick wall; can 6.21 ID x 0.200 wall



NOTES:

1. MATERIAL: ITEM 1: STAINLESS STEEL PLATE, TYPE 304, AS PER ASTM A-240.
   ITEM 2 & ITEM 3: FEEDTHRU TERMINAL, COPPER ALLOY C11000 OR APPROVED EQUIVALENT.

2. OPERATING CONDITIONS: 275 PSIA WORKING PRESSURE (344 PSIA MAX) APPLIED TO INSIDE FACE. MEDIUM IS HELIUM. TEMPERATURE RANGE IS 70°K TO 350°K. ( -205°C TO 70°C )

3. LEAK TIGHTNESS: LEAK RATE FOR ENTIRE FEEDTHROUGH ASSY FROM INSIDE FACE TO OUTSIDE FACE SHALL NOT EXCEED 2 X $10^{-10}$ATM CC/SEC He AS MEASURED IN ACCORDANCE WITH SPECIFICATION RHIC-CR-E-4703-0041.

4. TERMINAL RATINGS: TERMINAL "A" = 380A MINIMUM EACH (20°C)
   TERMINAL "B" = 30A EACH (20°C)
   VOLTAGE STANDOFF OF 5KV FROM EACH TERMINAL TO STAINLESS STEEL PLATE

5. APPROVED SOURCES OF SUPPLY:

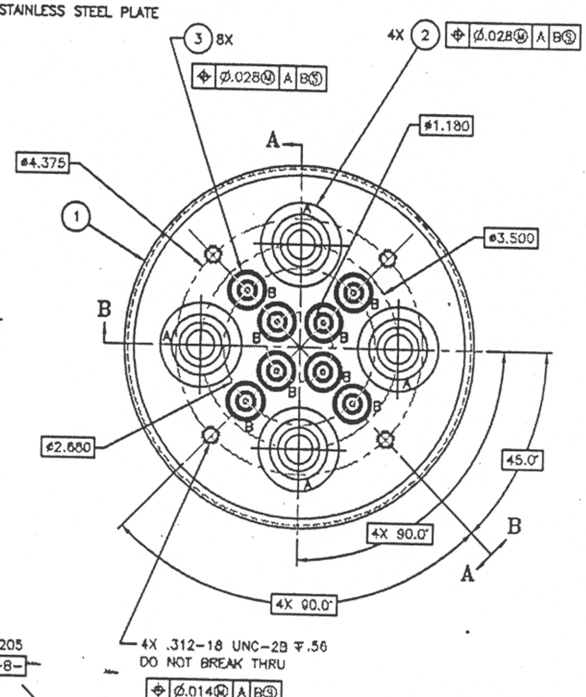
   CERAMASEAL, DIVISION OF CERAMX
   P.O. BOX 260, ROUTE 20, NEW LEBANON, NEW YORK 12125
   TEL: (518)794-7800

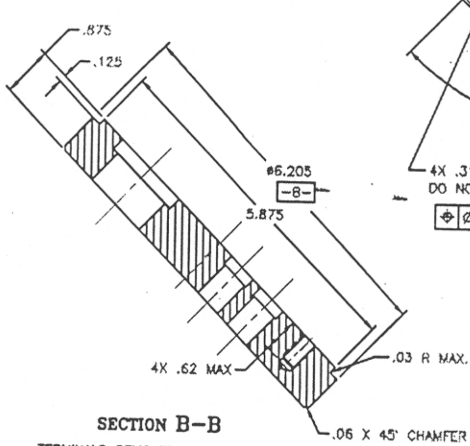
   PAVE TECHNOLOGY CO.INC.
   2751 THUNDERHAWK COURT
   DAYTON, OHIO 45414-3445
   TEL: (937)890 1100

6. IDENTIFICATION OF THE APPROVED SOURCES(S) HEREON IS NOT TO BE CONSTRUED AS A GUARANTEE OF PRESENT OR CONTINUED AVAILABILITY AS A SOURCE OF SUPPLY FOR THE ITEM DESCRIBED ON THIS DRAWING.

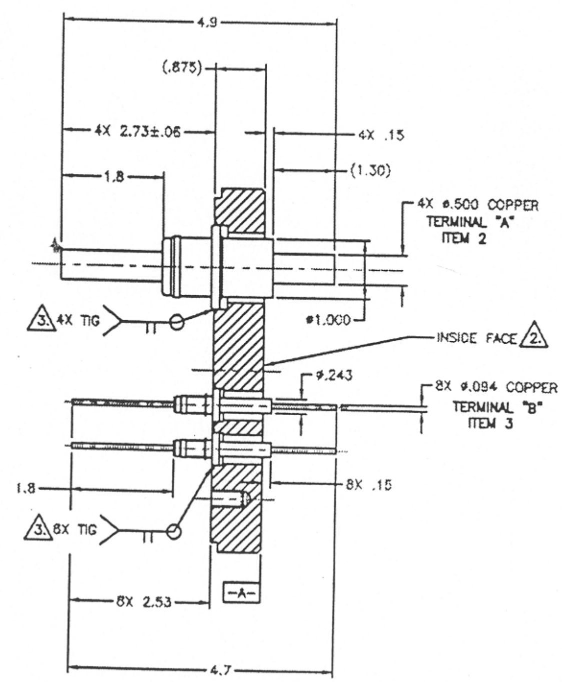
7. ONLY THE ITEM DESCRIBED ON THIS DRAWING WHEN PROCURED FROM THE SUPPLIER(S) LISTED HEREON IS APPROVED BY BROOKHAVEN NATIONAL LAB FOR USE IN THE APPLICATION SPECIFIED HEREON. A SUBSTITUTE ITEM SHELL NOT BE USED WITHOUT PRIOR APPROVAL BY BROOKHAVEN NATIONAL LAB.

8. BAG OR TAG WITH 12011385-APPLICABLE REV LTR PER MIL-STD-130.




SECTION B-B
TERMINALS REMOVED FOR CLARITY




SECTION A-A
FULL SCALE

| ITEM | QTY | COPPER DIAMETER |
|---|---|---|
| 2 | 4 | ø.500 |
| 3 | 8 | ø.094 |

SOURCE CONTROL DRAWING

| REVISIONS | | | | | | | |
|---|---|---|---|---|---|---|---|
| REV | ZONE | ECN NO. | DESCRIPTION | BY | DATE | CKR | APP |
| A | | | INITIAL RELEASE | JO | 1/21/00 | | |

RHIC

BROOKHAVEN NATIONAL LABORATORY
UPTON, N.Y. 11973

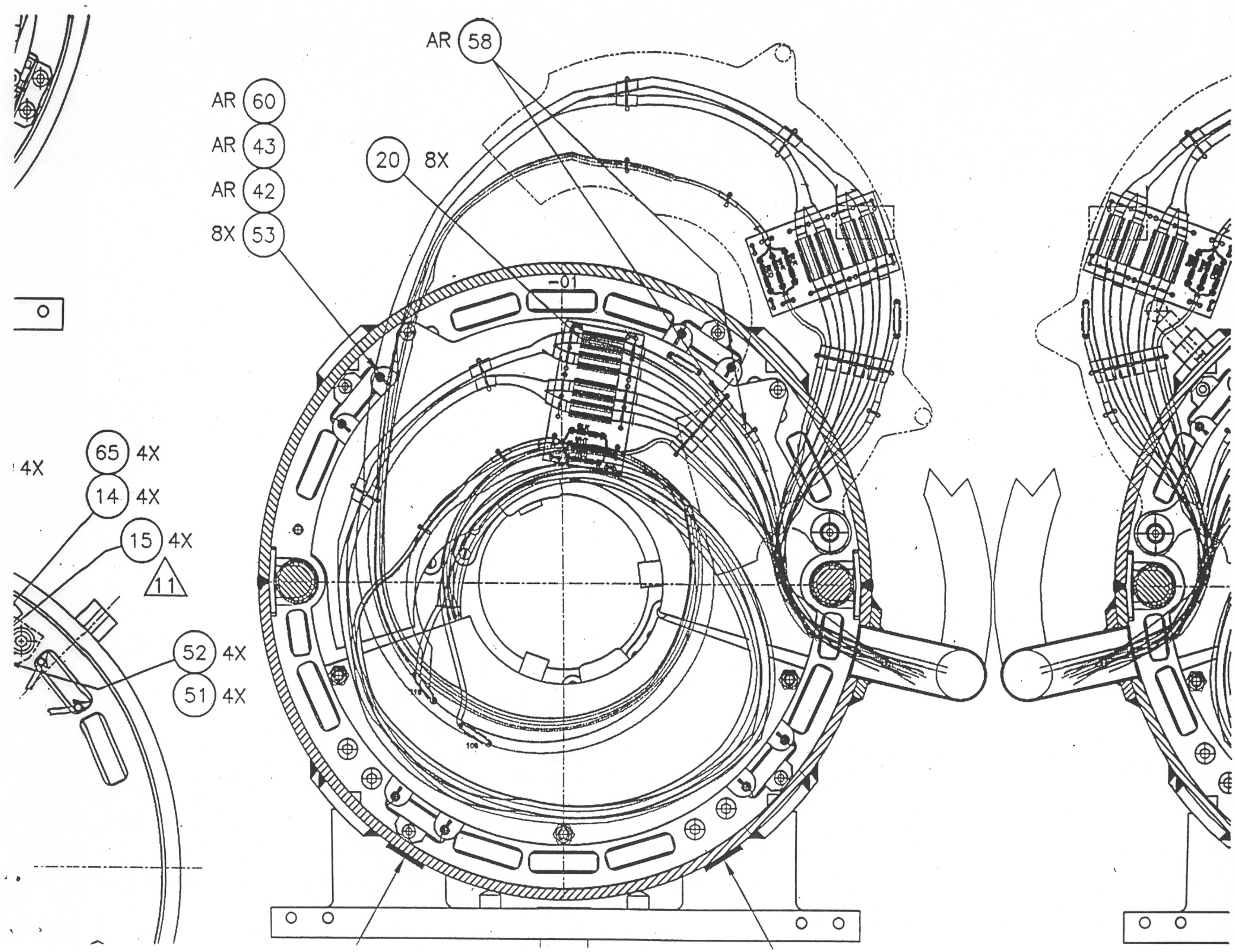
HELICAL MAGNET FEEDTHRU

J.OSTASZEWSKI 1/21/00
E.KILLIAN 1/26/00
A.YONKERS 1/26/00
E.KILLIAN 1/26/00
S.PLATE 1/26/00
C.PORRETTO 1/26/00

SIZE D DRAWING NUMBER 12011385 REV. A

SCALE 1/1 SHEET 1 of 1

DWG NO 12011385



AR 58
AR 60
AR 43
AR 42
8X 53
20 8X
-01
65 4X
4X
14 4X
15 4X
11
52 4X
51 4X

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lessard@bnl.gov

Managed by Brookhaven Science Associates
for the U.S. Department of Energy

***Date:*** *August 5, 2003*

***To:*** *T. Sheridan, Deputy Director for Operations*

***From:*** *E. Lessard, Chair, BNL Environment, Safety and Health Committee*

***Subject:*** LESHC 03-03, Recommendation for Approval of the RHIC Snake Magnet #1 Modification

The Cryogenic Safety Subcommittee of the BNL ES&H Committee has reviewed the proposed modifications to the RHIC Snake Magnet # 1 in our meeting of July 9, 2003. The power feedthroughs for Snake Magnet # 1 failed due to ice buildup between the insulating ceramic and the electrical conductors. In concert with the repair, the Collider-Accelerator Department (C-AD) proposed to modify the cryogenic design of the magnet to address the cause of this failure.
The Meeting Minutes are attached for your information.
The Committee recommends the approval of the proposed modifications to RHIC Snake Magnet # 1, subject to the following conditions.
The Collider-Accelerator Department (C-AD) will:

1. Review the Magnet Division calculation, "Helical Magnet Program, Power Lead Redesign" by S. Plate and M. Rehak, dated May 5, 2000 for applicability to this proposed design – **Complete**[1].
2. Include an additional anchor between the splice can and the turret – **Complete**[1].
3. Submit the rationale for the ODH access controls around the work area to the Committee – **Complete**[1].
4. Evaluate the hole in the head of the splice can for compliance with the ASME Boiler and Pressure Vessel (B&PV) Code – **Complete**[1].
5. Perform a pressure test of the modification prior to operation, per the ASME B&PV Code.

[1] Please note that conditions 1 through 4 have been completed in the interim between our July 9th meeting and the date of this letter.

.

CC w/ attachment (via Email):

LESHC Members
M. Beckman
A. Etkin
G. Ganetis
R. Karol

P. Kelley (BAO)
T. Kirk
D. Lowenstein
L. Marascia
G. McIntyre
T. Monahan
D. Ryan
T. Sheridan
J. Tarpinian

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for the U.S. Department of Energy

# Memo

***date:*** ***August 11, 2003***

***to:*** ***Derek Lowenstein***

***from:*** ***Thomas R. Sheridan***

***subject:*** ***Approval of the RHIC Snake Magnet #1 Modification***

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After review of the recommendation of the Cryogenic Safety Subcommittee of the Laboratory Environment, Safety & Health Committee (LESHC) (memo from E. Lessard, Chair, dated 8/5/03), I authorize approval of the proposed RHIC Snake Magnet #1 Modification, and understand that LESHC conditions 1-4 were already completed. Condition 5, "Perform a pressure test of the modification prior to operation, per the ASME B&PV Code", will be completed before modifications are begun.

TRS/lim

cc: E. Lessard
R. Travis